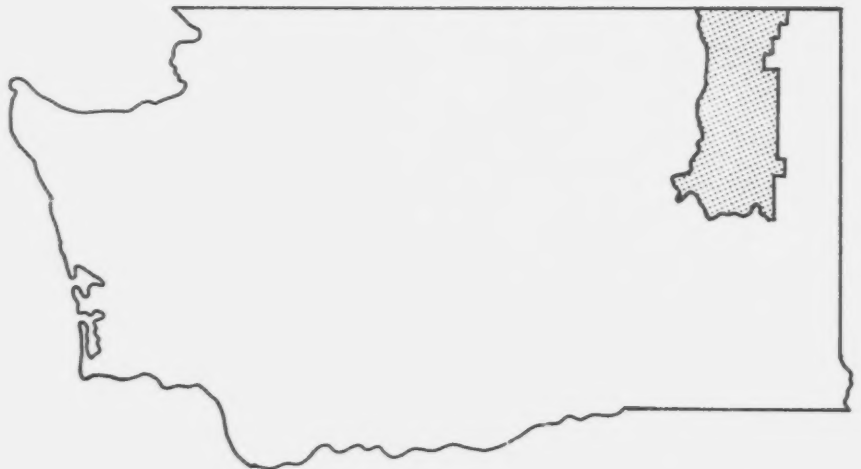


FEM 1.209: 530185

FLOOD INSURANCE STUDY



**STEVENS COUNTY,
WASHINGTON**
UNINCORPORATED AREAS



SEPTEMBER 14, 1990



Federal Emergency Management Agency

COMMUNITY NUMBER - 530185

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NOTICE TO
FLOOD INSURANCE STUDY USERS

Communities participating in the National Flood Insurance Program have established repositories of flood hazard data for floodplain management and flood insurance purposes. This Flood Insurance Study may not contain all data available within the repository. It is advisable to contact the community repository for any additional data.

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FLOOD INSURANCE STUDY
STEVENS COUNTY, WASHINGTON (UNINCORPORATED AREAS)

1.0 INTRODUCTION

1.1 Purpose of Study

This Flood Insurance Study investigates the existence and severity of flood hazards in the unincorporated areas of Stevens County, Washington, and aids in the administration of the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973. This study has developed flood risk data for various areas of the community that will be used to establish actuarial flood insurance rates and assist the community in its efforts to promote sound floodplain management. Minimum floodplain management requirements for participation in the National Flood Insurance Program (NFIP) are set forth in the Code of Federal Regulations at 44 CFR, 60.3.

In some States or communities, floodplain management criteria or regulations may exist that are more restrictive or comprehensive than the minimum Federal requirements. In such cases, the more restrictive criteria take precedence and the State (or other jurisdictional agency) will be able to explain them.

1.2 Authority and Acknowledgments

The sources of authority for this Flood Insurance Study are the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973.

The hydrologic and hydraulic analyses for this study were performed by Northwest Hydraulic Consultants (NHC), the Study Contractor, for the Federal Emergency Management Agency (FEMA), under Contract No. EMW-87-C-2472. This study was completed in May 1988.

1.3 Coordination

On October 7, 1986, an Initial Consultation and Coordination Officers' (CCO) meeting was held with representatives of FEMA, Stevens County, and the Study Contractor. Coordination with county officials and Federal, State, and regional agencies produced a variety of information pertaining to available community maps, flood history, and hydrologic data.

The results of the study were reviewed at the final CCO meeting held on October 26, 1989, and attended by representatives of the County, the City of Colville, and FEMA.

2.0 AREA STUDIED

2.1 Scope of Study

This Flood Insurance Study covers the unincorporated areas of Stevens County, Washington.

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Areas within the boundaries of Stevens County but not included in this study are the Cities of Chewelah and Colville and the Towns of Kettle Falls, Marcus, Northport, and Springdale. The City of Chewelah has a separately published Flood Insurance Study (Reference 1).

The area of study is shown on the Vicinity Map (Figure 1).

The areas studied by detailed methods were selected with priority given to all known flood hazard areas and areas of projected development or proposed construction through May 1992.

Riverine flooding was studied in detail for two separate reaches of the Colville River. The first reach near the Town of Colville, begins at the west border of Section 31, approximately 1,400 feet downstream of Gold Creek Road, and extends 5 miles upstream to the midpoint of Section 21, approximately 1,500 feet upstream of Mantz-Rickey Road. This reach of the Colville River was studied in detail, and a floodway analysis was performed.

The second reach of the Colville River is near the Town of Chewelah. This portion starts at Steinmetz Road and continues upstream 5.4 miles to the U.S. Highway 395 crossing. This reach was also studied by detailed methods, but no floodway analysis was performed.

Four tributaries of the Colville River near the community of Chewelah were studied by detailed methods. The study reaches for each stream are defined as follows:

Chewelah Creek - approximately 1 mile, from its confluence with the Colville River upstream to the southern corporate limits of the City of Chewelah, and from the northern corporate limits to the confluence of North Fork Chewelah Creek and South Forks Chewelah Creek

North Fork Chewelah Creek - 2 miles, from the northern corporate limits to the northern border of Section 2

South Fork Chewelah Creek - 1 mile, from the northern corporate limits to the northern border of Section 1

Paye Creek - a total of 2.1 miles, including the reaches from its confluence with the Colville River upstream to the western corporate limits of the City of Chewelah, and from the northern corporate limits upstream to a point about 0.6 mile upstream of Kramer Road

The final stream reach analyzed was the Columbia River from China Bend upstream to the U.S./Canada border, a distance of 27 miles. This reach was studied by approximate methods with limited detail.

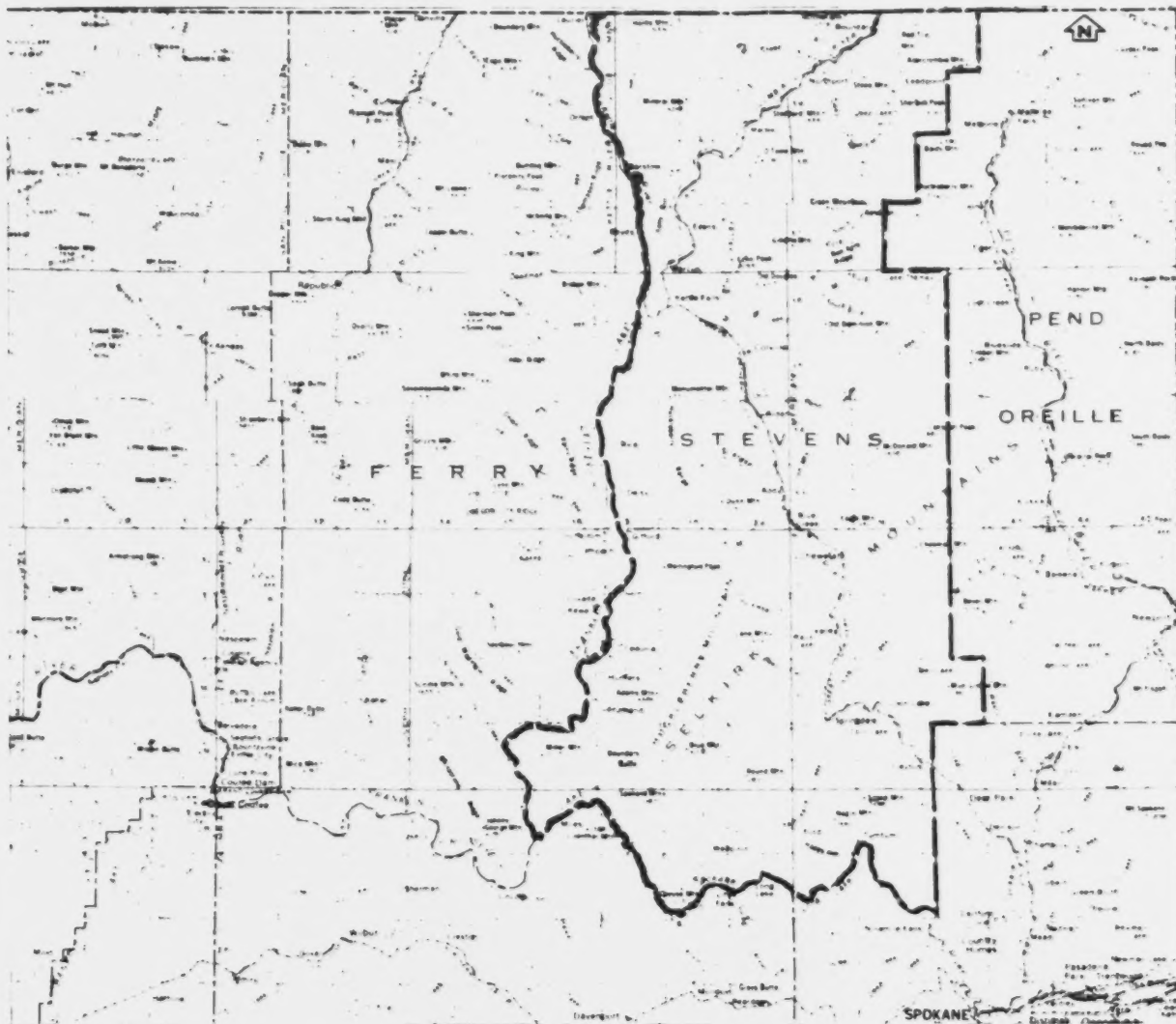


FIGURE 1

FEDERAL EMERGENCY MANAGEMENT AGENCY

STEVENS COUNTY, WA
 (UNINCORPORATED AREAS)

APPROXIMATE SCALE

16 0 16 32 48 MILES

VICINITY MAP

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Approximate analyses were used to study those areas having a low development potential or minimal flood hazards. The scope and methods of study were proposed to and agreed upon by FEMA and the County. The areas studied include two reaches of the Colville River and four tributaries, each analyzed by detailed methods, and one reach of the Columbia River analyzed in limited detail by approximate methods.

2.2 Community Description

Stevens County is located in the northeastern portion of the State of Washington. The county is bounded by British Columbia, Canada to the North, Pend, Orellie, and Spokane Counties to the East, Spokane and Lincoln Counties to the South, and Ferry County to the West. The Spokane River forms the southern boundary of Stevens County and the western boundary is formed by the Kettle and Columbia Rivers. The center of the county is about 50 miles north-northwest of the City of Spokane, Washington.

The population of Stevens County is distributed unevenly and is relatively sparse. According to the 1980 census, the county had an estimated population of 29,000, 28 percent greater than the estimated 1975 population of 22,708 (Reference 2). The Stevens County population is projected to increase to about 32,000 in 1990 and 35,500 in the year 2000 (Reference 3). Development within the county has occurred principally along the Colville River valley and its tributaries and is centered around six incorporated towns. Projected development includes recreational communities along the Columbia River, additional residences along the Colville River tributary creeks, and possible development in corridors parallel to the Colville River near the Towns of Colville and Chewelah.

The total area contained within Stevens County is 2,551 square miles, of which 1.5 percent is classified as urban. About 60 percent of the county is defined as forest-rangeland. In 1974, agricultural lands used primarily for crops and pasture represented 8.6 percent of the county area. Public open space lands account for 15.7 percent and the Spokane Indian Reservation represents 9.3 percent of county lands. The total land area associated with mines, quarries, roads, airfields, surface water, and rock outcrops is about 4 percent (Reference 2).

The major drainage basin in Stevens County is the Colville River basin, which covers 1,020 square miles and is almost entirely within the county boundaries. Altitudes within the basin range from 6,855 feet at the top of Calispell Peak to about 1,290 feet at the mouth of the Colville River.

The topography of the study area is generally a product of glacial activity that covered northern Washington during the Pleistocene Ice Age. Glacial ice has covered the study area during at least two time periods. The impact of the glaciation is evidenced by both the shape of the Colville River valley and the presence of extensive moraines and deposits of glacial outwash (Reference 4).

The climate of Stevens County is generally continental, due largely to the influence of the Cascade Range which forms a barrier to the west and shields the area from eastward-flowing marine air masses. The average annual precipitation ranges from less than 15 inches at a location 8 miles south of Colville to about 40 inches near Calispell Peak (Reference 4). Precipitation is distinctly seasonal with about two-thirds of the annual amount falling in a 6-month period from October to March.

Snowfall generally begins to occur by the end of October at the higher altitudes and by the end of November in the valleys. Total annual snowfall at the lower elevations ranges from 15 to 25 inches with extremes of 30 to 50 inches possible. Snow cover in the valleys during the winter is intermittent, although 15 to 30 inches have remained on the ground for over 30 days. Snow cover in the higher elevations ranges from 5 to 10 feet and may remain on the ground through June (Reference 2). The average annual temperature is 46°F (Reference 4).

2.3 Principal Flood Problems

The high flow on the Colville River and its tributaries generally occurs in the spring as a result of snowmelt. Rainfall seldom contributes significantly to spring floods. Occasionally, however, floods occur in January, February, or March due to a combination of rainfall and snowmelt. Summer thunderstorm events rarely produce extreme streamflows in the study region. The annual peaks recorded at the U.S. Geological Survey (USGS) gage No. 1240900 at Kettle Falls, Washington, on the Colville River in the past 63 years range from 220 cubic feet per second (cfs) on February 25, 1930, to 3,440 cfs on January 20, 1974. The annual peaks recorded on Chewelah Creek at USGS gage No. 1240770 near Chewelah, Washington, between 1957 and 1974 range from 75 cfs on May 22, 1964, to 392 cfs on January 17, 1974.

Some of the most serious floods on the Colville River occurred in 1904, 1956, and 1974 (Reference 5). According to newspaper accounts, each of these three floods caused the river to overflow its banks. The 1956 flood resulted from unseasonably warm temperatures which melted a heavy winter snowpack. Temperatures exceeded 65°F for nearly one week and reached 81°F at the Colville airport (Reference 6). The peak river flow was 3,230 cfs at Kettle Falls on April 23, 1956 (approximately a 50-year recurrence interval flood). The most severe flood recorded occurred in 1974 after temperatures climbed nearly 60°F from sub-zero levels, and rain had fallen for about a week. The Colville River at Kettle Falls peaked at 3,440 cfs on January 23, 1974 (approximately an 80-year recurrence interval flood). Ice jams are reported to have formed on many of the Colville River tributaries; however, there have been no specific reports of ice jams occurring on the tributaries included in this study (Reference 7).

Chewelah Creek also experienced serious flooding in 1956 and 1974. The 1956 event was caused by runoff from snowmelt, which was particularly heavy in the North Fork Chewelah Creek basin. In the Town of Chewelah, Chewelah Creek overflowed its banks, washed out two footbridges and threatened the footings of another bridge. Two 42-inch culverts in the town were unable to convey the high flows, and flooding occurred on nearby properties. Two bridges along North Fork Chewelah Creek were also washed out during this event (Reference 6). Estimates of Chewelah Creek peak flows during the 1956 flood are not available. In 1974 the Town of Chewelah experienced flooding which caused extensive damage to city streets and private homes (Reference 7). During this flood, Chewelah Creek flows peaked at 392 cfs on January 17, 1974 (approximately a 25-year recurrence interval flood). No flood damages along Paye Creek or South Fork Chewelah Creek were mentioned in newspaper accounts. Local residents and Chewelah city officials recalled no flood damage resulting from floods on Paye Creek.

Photographs taken during the 1956 and 1974 floods show flood conditions in the Colville River valley near Colville with the Colville River overflowing its banks, and in Chewelah with Chewelah Creek overflowing its banks (References 6, 7, 8). Unfortunately, the available photographs are of poor quality and could not be reproduced in this report.

2.4 Flood Protection Measures

Peak flows of the Columbia River at the international boundary are regulated by 28,633,000 acre feet of flood control storage. The operating authority for 20,492,000 acre feet of the total is the Columbia River Treaty because of its location in Canada. The U.S. Army Corps of Engineers (COE), North Pacific Division (NPD) serves (along with Bonneville Power Administration) as the U.S. entity in the implementation of the treaty, through which three Canadian storage projects have been planned and are operated by the U.S. for flood control. NPD is also responsible for regulating the 8,141,000 acre feet located in the U.S. at Libby and Hungry Horse. After treaty ratification in 1964, system-wide flood control operating studies were made by NPD to develop the interim "Columbia River Treaty Flood Control Operating Plan." These studies featured detailed daily routings for the record from 1929 to 1958 using the computer program "SSARR" (Streamflow Synthesis and Reservoir Regulation) and assumed 1975 storage conditions and estimated 1985 irrigation depletions. Output from the final routings was used by the COE, Seattle District, to develop frequency curves for natural and regulated conditions for the Columbia River at Grand Coulee, and by NPD to develop similar curves for the Columbia River at the Dalles. The curves for Grand Coulee were adjusted to reflect the longer record, 1958-1970, available at the Dalles.

3.0 ENGINEERING METHODS

For the flooding sources studied in detail in the community, standard hydrologic and hydraulic study methods were used to determine the flood hazard data required for this study. Flood events of a magnitude which are expected to be equaled or exceeded once on the average during any 10-, 50-, 100-, or 500-year period (recurrence interval) have been selected as having special significance for floodplain management and for flood insurance rates. These events, commonly termed the 10-, 50-, 100-, and 500-year floods, have a 10-, 2-, 1-, and 0.2-percent chance, respectively, of being equaled or exceeded during any year. Although the recurrence interval represents the long term average period between floods of a specific magnitude, rare floods could occur at short intervals or even within the same year. The risk of experiencing a rare flood increases when periods greater than 1 year are considered. For example, the risk of having a flood which equals or exceeds the 100-year flood (1-percent chance of annual exceedence) in any 50-year period is approximately 40 percent (4 in 10), and for any 90-year period, the risk increases to approximately 60 percent (6 in 10). The analyses reported herein reflect flooding potentials based on conditions existing in the community at the time of completion of this study. Maps and flood elevations will be amended periodically to reflect future changes.

3.1 Hydrologic Analyses

Hydrologic analyses were carried out to establish peak discharge-frequency relationships for each flooding source studied in detail affecting the community.

Peak discharge-drainage area relationships for various locations along the Colville River, Chewelah Creek and its tributaries, Paye Creek, and the Columbia River are shown in Table 1. Below is a description of the Hydrology Analysis for the studied streams:

a. Columbia River

Correspondence with staff of the U.S. Bureau of Reclamation (USBR) Pacific Northwest Region office in Boise, Idaho, led to the acquisition of a 1940 report (Reference 9) that presents the results of a study which analyzed backwater effects created by the Grand Coulee Dam. Investigators computed backwater profiles for two reservoir conditions: the existing (1940) natural condition, and the condition which would exist if a large rock island choking the entrance to the Little Dalles was removed. Profiles were constructed for the range of flows from 100,000 to 650,000 cfs. To confirm which condition best represents present-day reservoir conditions, USBR staff reviewed past construction records, and determined that the rock island was, in fact, removed in 1940. The profiles for the Little Dalles island excavation were therefore used to estimate the 10-, 50-, 100-, and 500-year flood profiles.

The Columbia River profiles were constructed from the 194C profiles using linear interpolation. 100-year floodplain boundaries were drawn on 7.5 minute, 1:2,000 USGS quadrangle maps (Reference 10).

In 1984 NPD began a major hydrologic and reservoir system analysis study to review flood control criteria for major reservoirs and assess system flood control capability. New proposed revised rule curves for five projects, including Libby and Hungry Horse, were used to route five floods through the Columbia River system to Vancouver, Washington. NPD provided the study contractor with detailed daily routings for the 1948, 1954, 1956, 1972, and 1974 floods to use to determine a revised frequency curve for Grand Coulee. NPD also provided a new discharge-frequency curve for the Columbia River at the Dalles unregulated spring-summer events. The curve was computed with the HECWRC model, which employs the current Water Resources Council Guidelines for flood frequency analysis, and used the period of record 1958-1985.

The new routings indicate that the regulated frequency curve should be adjusted upward slightly at Grand Coulee, but that most of the adjustment results from changes in operating the Grand Coulee reservoir itself, rather than upstream reservoirs. A comparison of the old frequency curve and new frequency curve at the Dalles indicates that adjustment of the unregulated curve at Grand Coulee is unwarranted. The 1-percent exceedence frequency event for the international boundary is estimated using the frequency curves for Grand Coulee, a relationship between natural and regulated inflows to Grand Coulee reservoir using both 1960's and 1987 data, and a relationship between regulated Grand Coulee inflow and regulated flow at the international boundary for the five newly routed floods. The general methodology was reviewed with NPD and COE, Seattle District, hydrologists and agreed upon in general. A summary of peak flood discharges for the Columbia River is presented in Table 1.

b. Colville River near Colville

Flow frequencies on the Colville River near Colville were based on a statistical analysis of USGS gage data. The 67-year record of peak flows at the USGS gage at Kettle Falls was analyzed in accordance with the criteria outlined in Bulletin 17B (Reference 11). A computer program developed by the COE (Reference 12) was used to analyze the gage data and determine the flow frequency relationship. The analysis was performed for peak annual flows from 1923 through 1986, using a generalized skew coefficient. The flow frequency relationship developed for the Colville River at Kettle Falls was used, without adjustment, for the Colville River at the downstream study limit. No significant inflow occurs in the 6-mile river reach between these two points.

Table 1. Summary of Discharges

<u>Flooding Source and Location</u>	<u>Drainage Area (Square Miles)</u>	<u>Peak Discharges (cfs)</u>			
		<u>10-Year</u>	<u>50-Year</u>	<u>100-Year</u>	<u>500-Year</u>
Columbia River					
At USGS gage at International Boundary	59,700	310,000	350,000	370,000	410,000
Colville River					
At USGS gage near Kettle Falls (Sta. 1240900)	1,007	2,310	3,220	3,570	4,320
Above its confluence with Mill Creek	828	1,950	2,810	3,180	4,070
At Steinmetz Road near Chewelah	414	947	1,320	1,460	1,770
Above its confluence with Chewelah Creek	320	729	1,020	1,120	1,360
Chewelah Creek					
At USGS gage near Chewelah (Sta. 1240770)	94.1	317	462	526	680
North Fork Chewelah Creek					
At its confluence with South Fork Chewelah Creek	60.3	203	296	337	435
South Fork Chewelah Creek					
At its confluence with North Fork Chewelah Creek	33.8	114	166	189	245
Split Flow - East Branch		77	108	120	150
Split Flow - West Branch		37	58	69	95
Paye Creek					
At its confluence with the Colville River	2.5	38	65	77	117
At U.S. Route 395, northern corporate limits of Chewelah	2.0	15	30	37	60

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A discharge-frequency relationship was also determined for the Colville River just upstream from the mouth of Mill Creek (about 0.7 mile upstream from the downstream study limit). Because only 6 years of record are available for Mill Creek at its mouth, daily flows at the mouth were generated from the 45-year record at an upstream USGS gage, Mill Creek near Colville. The recorded flows coinciding with annual peak events on the Colville River were adjusted to represent flows at the mouth by using a linear relationship developed from the 6 concurrent years of data at both gages. The adjusted Mill Creek discharges were then subtracted from coincident Colville River discharges, and a frequency analysis of the net flows was performed to develop the appropriate discharge-frequency relationship.

c. Colville River near Chewelah

No adequate record exists of streamflows for the Colville River in the vicinity of Chewelah. The nearest gaging station is located at Blue Creek, 3.6 river miles downstream of the downstream study limit. However, only 6 years of streamflow were recorded at that site. Therefore, the discharge-frequency relationship was developed on the basis of the discharges determined for the Colville River at Kettle Falls, with a linear adjustment for contributing drainage area. Although the streamflow record for the Colville River at Blue Creek is considered inadequate for a statistical analysis, the peak annual flows were compared to peak annual flows at Kettle Falls during the same period. The resulting ratio of Blue Creek flows to Kettle Falls flows agreed favorably with the ratio of contributing drainage areas.

The discharge-frequency relationship developed for the Colville River upstream of Chewelah Creek was adjusted to account for the contributing drainage area represented by the Chewelah Creek sub-basin.

d. Chewelah Creek

A flow frequency relationship previously developed for Chewelah Creek (Reference 13) was reviewed, and an independent statistical analysis of the USGS gage data was performed. The two analyses generally agreed. Therefore, the previously developed discharge frequency data were used in this study without adjustment.

e. North Fork Chewelah Creek

No streamflow data are available for North Fork Chewelah Creek. Consequently, the discharge-frequency relationship was computed by adjusting the mainstem Chewelah Creek flows based upon a ratio of contributing drainage areas of 0.64.

f. South Fork Chewelah Creek

Streamflow records do not exist for South Fork Chewelah Creek. The appropriate discharge-frequency relationship was determined by adjusting mainstem Chewelah Creek flows based upon a ratio of contributing drainage areas of 0.36.

3. Paye Creek

The Soil Conservation Service (SCS) published a Floodplain Management Study of the City of Chewelah in 1982 (Reference 13). The study area extended to the corporate boundary of the city and addressed potential flooding on Chewelah Creek, Paye Creek, and Thomason Creek. Flood flows on Chewelah Creek were estimated by analyzing observed data, whereas flows on the ungaged Paye Creek were estimated using the TR-20 computer model (Reference 14). A summary of flood flows determined by the SCS for Chewelah Creek and Paye Creek is given in Table 2. A review of the SCS analysis indicates that Paye Creek flows have been significantly overestimated. The following is a brief discussion of findings which led to this conclusion, and the presentation of an alternative analysis of flood flows.

It can be seen from Table 2 that runoff per square mile for flows computed by the SCS for Paye Creek is from 9 to 18 times greater than runoff observed on Chewelah Creek. Even allowing for the effects of scale (watershed size), soil types, and urbanization, the differences between computed and observed runoff appear to be too large for the computed flows to be correct.

Examination of the SCS flood profiles for Paye Creek shows that, with the published computed flows, flooding of areas near Washington Avenue and Chewelah Avenue in Chewelah would occur at least once every 10 years on average. However, conversations with the acting Public Works Director of the city indicate that flooding has not occurred on Paye Creek in Chewelah in recent memory. Furthermore, no mention of floods on Paye Creek has been found in NHC's review of newspaper files pertaining to flooding in Chewelah.

Review of SCS work files shows that the flows published for Paye Creek at the northern city limits inadvertently included contributions from the downstream developed area within the city limits. However, this error does not affect the flow estimates at the southern city limit which still appear to be much too large. SCS flow estimates for Paye Creek at the northern city limit have been revised by removing the urban contribution, and are shown in Table 2 along with the published values.

Note that with the above revision, the flows increase substantially between the northern and southern city limits, reflecting the computed effects of urbanization which appear,

Table 2. Comparison of Flood Discharges
Determined by Previous Study

<u>Location</u>	<u>Drainage Area (Square Miles)</u>	<u>Peak Discharges (cfs, cfs/square mile)</u>			
		<u>10-Year</u>	<u>50-Year</u>	<u>100-Year</u>	<u>500-Year</u>
Chewelah Creek at USGS gage	94.1	317 (3.4)	462 (4.9)	526 (5.6)	680 (7.2)
Paye Creek at northern city limit	2.0	87 (43.5)	161 (80.5)	193 (96.5)	269 (134.5)
Paye Creek at southern city limit	2.5	79 (31.6)	152 (60.8)	183 (73.2)	261 (104.4)
Paye Creek at northern city limit (SCS estimate, reviewed by NHC)	2.0	15 (7.5)	55 (27.5)	76 (38.0)	133 (66.5)

in this case, to have been greatly overestimated by the TR-20 model. The principal difficulty in the model developed by the SCS is that it appears to assume a highly efficient system for conveying stormwater from the residential area of Chewelah into Paye Creek. The developed area of Chewelah which contributes to Paye Creek is an older residential area with minimal storm drainage facilities. Less than 10 percent of the area has curb and gutter improvement, and there is very little open ditch drainage. Runoff from the developed areas follows the natural grade of the land and is mostly lost by seepage into the ground. The existing stormwater conveyance facilities cannot physically produce the increase in flows predicted by the SCS.

An alternative method for determining flows on Paye Creek is available in the form of regional flood frequency techniques developed by the USGS. The appropriate techniques for this area are described in two reports. The publication "Magnitude and Frequency of Floods in Washington," USGS Open-File Report 74-336 (Reference 15), describes methods for determining flood magnitude and frequency for undeveloped areas, such as for Paye Creek above the northern city limit of Chewelah. The publication "Flood Characteristics of Urban Watersheds in the United States", USGS Water-Supply Paper 2207 (Reference 16), describes methods for estimating flood magnitude and frequency for streams affected by urbanization, such as for Paye Creek below the City of Chewelah. Flows estimated by these techniques, together with estimates of the 5 percent and 95 percent confidence limits, are given in Table 3. Comparison of Table 2 and Table 3 shows that flows published by the SCS generally fall outside the 5 percent and 95 percent confidence bounds of flows determined by the USGS regional technique.

The discrepancy between the previously developed discharges and the proposed discharges developed by the regional method were discussed with the FEMA Project Officer. The flows proposed by the study contractor were adopted for this study after approval by the Project Officer.

3.2 Hydraulic Analysis

Analyses of the hydraulic characteristics of flooding from the sources studied were carried out to provide estimates of the elevations of floods of the selected recurrence intervals.

Locations of selected cross sections used in the hydraulic analyses are shown on the Flood Profiles (Exhibit 1). For stream segments for which a floodway was computed (Section 4.2), selected cross section locations are also shown on the Flood Insurance Rate Map (Exhibit 2).

Water-surface elevations for the Colville River and its tributaries were computed using the COE HEC-2 step-backwater computer program (Reference 17). The data required for the computations include

Table 3. Flood Discharges on Paye Creek
Estimated by USGS Regional Methods

Location		Peak Discharges (cfs)			
		10-Year	50-Year	100-Year	500-Year
Paye Creek at northern city limit ¹	5% ²	7	13	15	N/A
	mean	15	30	37	60
	95% ²	31	70	93	N/A
Paye Creek at southern city limit ³	5%	20	32	37	51
	mean	38	65	77	117
	95%	73	132	161	267

¹Estimated from "Magnitude and Frequency of Floods in Washington," USGS Open-File Report 74-336.

²Approximate estimates only. Confidence limits not directly available.

³Estimated from "Flood Characteristics of Urban Watersheds in the United States," USGS Water-Supply Paper 2207.

flow regime, channel and floodplain geometry, starting elevations, and roughness coefficients.

Above-water cross section data for the backwater analyses on the Colville River and its tributaries were obtained from topographic maps. The maps were compiled (at a scale of 1:4,800 with a contour interval of 4 feet) from aerial photographs taken specifically for this study in October 1987 (Reference 18). The below-water sections were obtained by field surveys performed in October and November 1987 by the study contractor. A total of 87 river sections were surveyed. Similarly, all bridges and culverts were surveyed by the study contractor to determine elevation data, structural geometry, and channel geometry at each structure. A total of 9 bridges and 12 culverts were measured.

Starting water-surface elevations for the Colville River were based upon normal-depth computations. Starting water-surface elevations for Chewelah Creek at the City of Chewelah's northern corporate boundary were based upon the results of a previous flood study (Reference 13). For Paye and Chewelah Creeks, at their confluences with the Colville River, and for Paye Creek at Chewelah's northern corporate boundary, starting elevations were based upon normal depth.

Channel and overbank roughness values (as represented by Manning's "n") used in the hydraulic computations were chosen by engineering judgment based upon field inspection and photo documentation, and by reference to classical publications (References 19 and 20). The channel "n" values for the Colville River ranged from 0.026 to 0.033, and the overbank "n" values ranged from 0.080 to 0.100. For Paye Creek, Chewelah Creek, and both forks of Chewelah Creek, the channel "n" values varied from 0.025 to 0.035, and the overbank "n" value was 0.080. The lower channel roughness coefficients reflect relatively straight and clean channels, light vegetation on the banks, and full stage. The higher values represent heavier vegetation on the banks, narrower and more winding channels, and low stage. The lowest overbank roughness values are appropriate for grassy floodways with shallow depths and very slow velocities (Reference 21). The highest overbank "n" values reflect dense brush in the floodplain.

Water-surface elevations at each bridge were computed using the COE HEC-2 backwater model. The special bridge routing was used for bridges with piers and for bridges where pressure flow occurred. The normal bridge routine was used for bridges without piers, for low flow conditions where the water surface was below the low chord elevation of the bridge. Wooden bridges and some small private bridges for foot and animal traffic were not included in the models because they do not have roadway embankments or because they are considered unlikely to withstand overtopping.

Water-surface elevations for each culvert were computed from established culvert nomographs (Reference 22) or from a culvert rating program developed by the COE, St. Louis District

(Reference 23). The computed headwater elevations were input to the backwater model with the X5 card option. The vast majority of the culverts in this study are comparatively short and have steep slopes, with the result that the culvert inlet generally controls the flow. For these conditions, it was considered preferable to analyze culvert hydraulics explicitly, external to the HEC-2 program.

The backwater model used in this study simplifies the analysis of river hydraulics by adopting the following assumptions:

1. Flow is steady.
2. Flow is gradually varied.
3. Flow is one-dimensional.
4. River channels have small slopes (less than 1:10).
5. Friction slope is constant for a given cross section.

For the most part, these assumptions apply to the present study condition. However, it was occasionally necessary to create a quasi-one-dimensional representation (in the HEC-2 model) of complex, two-dimensional floodplain flows. This was generally accomplished by using engineering judgment to define those areas of the floodplain which would not effectively convey flood flows, and by treating them as follows:

1. Areas in the floodplain which would be inundated but not effective in conveying flow were eliminated from the cross section.
2. Flow areas which would be rendered ineffective by the presence of hydraulic structures were defined in the model.
3. Low overbank areas of any cross section were eliminated if the water-surface elevation was lower than the top-of-bank level, and if the water could not enter the overbank at a location upstream from that section.

Ineffective flow areas in the floodplain geometry, such as local depressions in the valley floor, were deleted from some cross sections and replaced with an average valley-floor elevation. Ineffective-flow areas where ponding would occur were described in the backwater model as areas with very high roughness coefficients.

The third method of establishing ineffective-flow areas was used judiciously in the model and frequently re-evaluated to best represent the actual flood condition. Specifically, the banks of the Colville River near Colville have naturally developed as berms, and the overbank areas are often lower than the top of the banks. To analyze this case, a computer model was first developed which used the effective area option and confined the flow to the channel unless the water-surface elevation exceeded the top of the berm (in which case the entire overbank became an effective conveyance

area). The water-surface elevation at each section in the model was computed in this manner without considering upstream conditions. The results from this "in-channel" model show that the 10-year discharges would generally remain in the channels and that higher discharges would cause the berms to be overtopped at certain locations along the river reach. This model was used to obtain estimates of base flood elevation within the channel itself, which might occur before the natural berms would fail.

A second model was then developed to more realistically represent flooding in the overbank for the higher discharges. The ineffective flow option was eliminated in the "floodplain" model at cross sections downstream of locations where the berms were first overtopped, according to the "in-channel" model results. At a given cross section, the water-surface elevation in the channel and in the floodplain was assumed to be equal. This approach to determining flood elevations in the floodplain is considered appropriate because of the unique nature of the natural berms, which are composed of a non-cohesive soil and have widely varying height and width. Once overtopped, the berms would rapidly erode. The final model thus assumed that the berms, along the channel downstream of areas where overtopping occurred, would not effectively confine the flow to the channel.

The hydraulic analyses for this study were based on unobstructed flow. The flood elevations shown on the profiles are thus considered valid only if hydraulic structures remain unobstructed, operate properly, and do not fail.

Elevation reference marks (ERMs) were established in and near the floodplains of each stream studied. All elevations are referenced to the National Geodetic Vertical Datum of 1929 (NGVD). ERMs used in this study are shown on the maps; the descriptions of the marks are presented in Elevation Reference Marks (Exhibit 3).

3.3 Alluvial Fan Analysis

Within the study limits, South Fork Chewelah Creek emanates from a canyon and traverses an alluvial fan before joining the mainstem of Chewelah Creek. The fan expands at an angle of about 65° from its apex, and has a surface slope of approximately 0.020. Fan length is about 7,000 feet, and the toe of the fan is located just within the northeastern city limits of Chewelah. The fan is more or less conical in shape, and numerous channel remnants are evident on the fan surface, indicating that the main channel has occupied positions virtually everywhere across the fan during recent geologic history. Presently, the main channel bifurcates into east and west branches about 1,500 feet downstream from the apex of the fan. Upstream from the bifurcation, the channel width and depth are approximately 10 feet and 4 feet, respectively. The downstream channels each have a width and depth of about 5 feet and 3 feet, respectively. The distribution of flow between the two branches is variable and depends upon local patterns of sediment deposition and

debris accumulation. Both coarse sediment and large debris appear to be abundant in the canyon upstream from the fan apex.

Development on the fan includes residences (at a rather low density of about one dwelling per 12 acres) and agriculture. More than 90 percent of the fan surface is used for grazing cattle and growing crops; tree cover exists mainly along streambanks and near dwellings. A network of paved roads exists on the fan. Although roads are generally at grade, embankments and drainage works exist which influence floodplain hydraulics to some degree.

As part of the detailed-study hydraulic analysis, a HEC-2 model was developed for both the east and west branches of South Fork Chewelah Creek. The model revealed that, in the absence of flow control by two culverts passing beneath Burnt Valley Road, the east and west branches of South Fork Chewelah Creek would have a combined capacity sufficient to carry the 100-year flow in-channel to the mainstem of Chewelah Creek. However, an analysis of culvert hydraulics at the Burnt Valley Road site indicated that for 50-year and greater flows, ponding would occur to the extent that a diversion of flow would take place to the west along the north side of the road embankment. The diverted flow would tend to travel in a southwesterly direction, but its path would be influenced by the presence of roads and channel remnants.

Because of the difficulty in analyzing such a complex flow process with the one-dimensional HEC-2 model, and because of the physical evidence of historical alluvial fan behavior, an additional analysis of flood risk was made using the alluvial fan criteria set out in the FEMA Flood Insurance Study guidelines (Reference 24). This procedure assumes that an equal probability exists for the main channel to be located at each location across the fan, and that channel dimensions can be predicted on the basis of generalized equations founded in fluvial geomorphology. Although the FEMA alluvial-fan criteria predict modest flow depths (less than 1 foot) and velocities (4 feet per second (fps) or less), note that bankfull velocities in the existing main channel range from 10 to 15 fps. Hence, property subjected to attack by a major channel anywhere on the fan would experience severe but localized erosion and shallow inundation.

4.0 FLOODPLAIN MANAGEMENT APPLICATION

The NFIP encourages State and local governments to adopt sound floodplain management programs. Therefore, each Flood Insurance Study provides 100-year flood elevations and delineations of the 100- and 500-year floodplain boundaries and 100-year floodway to assist communities in developing floodplain management measures.

4.1 Floodplain Boundaries

To provide a national standard without regional discrimination, the 1-percent annual chance (100-year) flood has been adopted by FEMA

as the base flood for floodplain management purposes. The 0.2-percent annual chance (500-year) flood is employed to indicate additional areas of flood risk in the community. For each stream studied in detail, the 100- and 500-year floodplain boundaries have been delineated using the flood elevations determined at each cross section. Between cross sections, the boundaries were interpolated using topographic maps at scales of 1:2,000 and 1:4,800, with a contour interval of 4 feet (References 10 and 18).

The 100- and 500-year floodplain boundaries are shown on the Flood Insurance Rate Map (Exhibit 2). On this map, the 100-year floodplain boundary corresponds to the boundary of the areas of special flood hazards (Zones A and AE), and the 500-year floodplain boundary corresponds to the boundary of areas of moderate flood hazards. In cases where the 100- and 500-year floodplain boundaries are close together, only the 100-year floodplain boundary has been shown. Small areas within the floodplain boundaries may lie above the flood elevations but cannot be shown due to limitations of the map scale and/or lack of detailed topographic data.

For the streams studied by approximate methods, only the 100-year floodplain boundary is shown on the Flood Insurance Rate Map (Exhibit 2).

Approximate 100-year floodplain boundaries in some portions of the study area were taken directly from the Flood Hazard Boundary Map (Reference 25).

4.2 Floodways

Encroachment on floodplains, such as structures and fill, reduces flood-carrying capacity, increases flood heights and velocities, and increases flood hazards in areas beyond the encroachment itself. One aspect of floodplain management involves balancing the economic gain from floodplain development against the resulting increase in flood hazard. For purposes of the NFIP, a floodway is used as a tool to assist local communities in this aspect of floodplain management. Under this concept, the area of the 100-year floodplain is divided into a floodway and a floodway fringe. The floodway is the channel of a stream, plus any adjacent floodplain areas, that must be kept free of encroachment so that the 100-year flood can be carried without substantial increases in flood heights. Minimum Federal standards limit such increases to 1.0 foot, provided that hazardous velocities are not produced. The floodways in this study are presented to local agencies as minimum standards that can be adopted directly or that can be used as a basis for additional floodway studies.

The floodways presented in this study were computed for certain stream segments on the basis of equal conveyance reduction from each side of the floodplain. Floodway widths were computed at cross sections. Between cross sections, the floodway boundaries were interpolated. The results of the floodway computations are

tabulated at selected cross sections (Table 4). In cases where the floodway and 100-year floodplain boundaries are either close together or collinear, only the floodway boundary has been shown.

The area between the floodway and 100-year floodplain boundaries is termed the floodway fringe. The floodway fringe encompasses the portion of the floodplain that could be completely obstructed without increasing the water-surface elevation of the 100-year flood more than 1.0 foot at any point. Typical relationships between the floodway and the floodway fringe and their significance to floodplain development are shown in Figure 2.

Floodways were analyzed for five miles of the Colville River near Colville. Floodways were not analyzed for the Colville River tributaries, namely Paye Creek, Chewelah Creek, and North Fork and South Fork Chewelah Creek, because the 100-year discharge would be confined to the channel for more than 50 percent of the channel length.

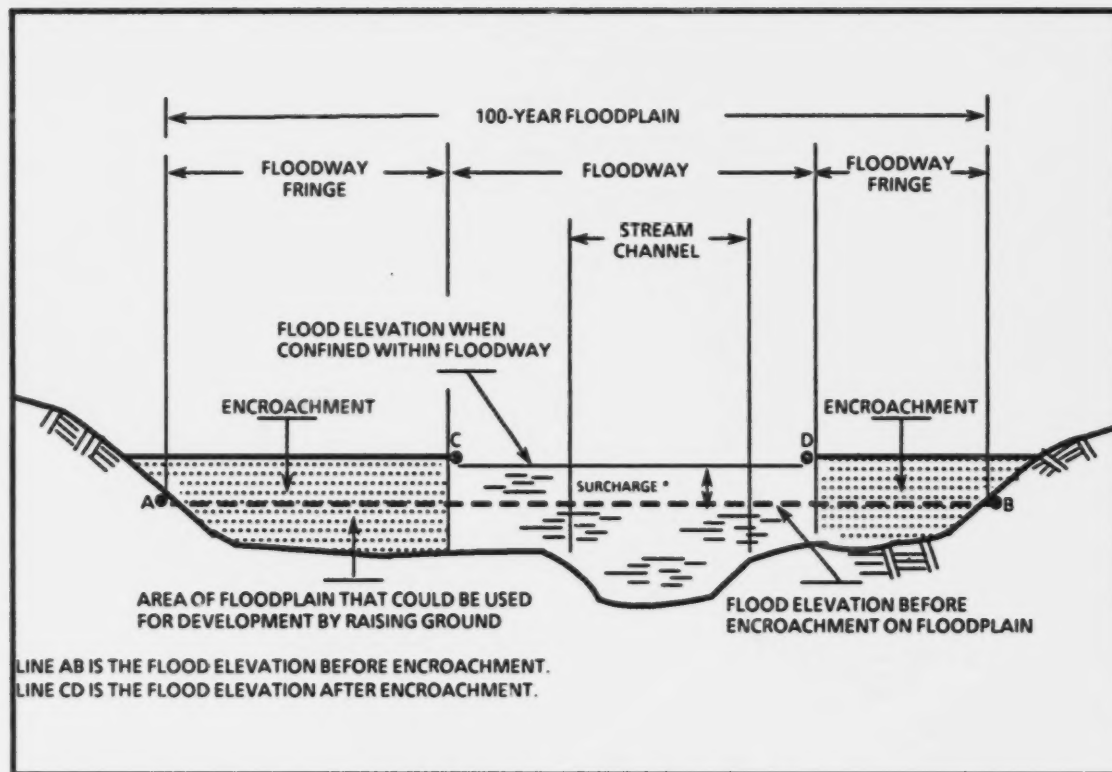


Figure 2. Floodway Schematic

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE ¹	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
(FEET NGVD)								
Colville River								
A	-1,400	129	631	5.7	1,537.3	1,537.3	1,538.3	1.0
B	-708	95	645	5.5	1,538.4	1,538.4	1,539.0	0.6
C	-20	75	651	5.5	1,538.9	1,538.9	1,539.4	0.5
D	720	105	463	7.7	1,539.3	1,539.3	1,539.6	0.3
E	2,200	103	610	5.2	1,541.4	1,541.4	1,541.8	0.4
F	3,400	293	880	3.6	1,542.1	1,542.1	1,542.7	0.6
G	5,040	1,323	2,915	1.1	1,542.7	1,542.7	1,543.5	0.8
H	6,620	1,064	2,402	1.3	1,543.0	1,543.0	1,544.0	1.0
I	8,950	657	2,162	1.5	1,543.7	1,543.7	1,544.7	1.0
J	11,270	784	2,154	1.5	1,544.5	1,544.5	1,545.4	0.9
K	12,830	104	690	4.6	1,545.0	1,545.0	1,546.0	1.0
L	14,310	69	573	5.6	1,546.2	1,546.2	1,546.9	0.7
M	14,954	97	594	5.4	1,547.1	1,547.1	1,547.4	0.3
N	16,954	1,099	2,330	1.4	1,548.0	1,548.0	1,548.6	0.6
O	19,074	923	1,123	2.8	1,548.5	1,548.5	1,549.2	0.7
P	20,574	554	620	5.1	1,549.2	1,549.2	1,550.0	0.8
Q	20,774	89	575	5.5	1,549.4	1,549.4	1,550.4	1.0
R	21,494	89	632	5.0	1,550.2	1,550.2	1,551.0	0.8
S	22,334	109	768	4.1	1,550.8	1,550.8	1,551.6	0.8
T	22,974	110	670	4.7	1,551.3	1,551.3	1,551.9	0.6
U	24,454	84	606	5.2	1,552.2	1,552.2	1,552.7	0.5
V	25,174	65	694	4.6	1,552.7	1,552.7	1,553.2	0.5
W	25,723	101	601	5.3	1,553.2	1,553.2	1,553.7	0.5
X	26,663	97	587	5.4	1,554.3	1,554.3	1,554.6	0.3

¹Feet Above Gold Creek Road

T
A
B
L
E

4

FEDERAL EMERGENCY MANAGEMENT AGENCY

STEVENS COUNTY, WA
(UNINCORPORATED AREAS)

FLOODWAY DATA

COLVILLE RIVER

21

5.0 INSURANCE APPLICATION

For flood insurance rating purposes, flood insurance zone designations are assigned to a community based on the results of the engineering analyses. These zones are as follows:

Zone A

Zone A is the flood insurance rate zone that corresponds to the 100-year floodplains that are determined in the Flood Insurance Study by approximate methods. Because detailed hydraulic analyses are not performed for such areas, no base flood elevations or depths are shown within this zone.

Zone AE

Zone AE is the flood insurance rate zone that corresponds to the 100-year floodplains that are determined in the Flood Insurance Study by detailed methods. Whole-foot base flood elevations derived from the detailed hydraulic analyses are shown at selected intervals within this zone.

Zone X

Zone X is the flood insurance rate zone that corresponds to areas outside the 500-year floodplain, areas within the 500-year floodplain, areas of 100-year flooding where average depths are less than 1 foot, areas of 100-year flooding where the contributing drainage area is less than 1 square mile, and areas protected from the 100-year flood by levees. No base flood elevation or depths are shown within this zone.

6.0 FLOOD INSURANCE RATE MAP

The Flood Insurance Rate Map is designed for flood insurance and floodplain management applications.

For flood insurance applications, the map designates flood insurance rate zones as described in Section 5.0 and, in the 100-year floodplains that were studied by detailed methods, shows selected whole-foot base flood elevations or average depths. Insurance agents use the zones and base flood elevations in conjunction with information on structures and their contents to assign premium rates for flood insurance policies.

For floodplain management applications, the map shows by tints, screens, and symbols, the 100- and 500-year floodplains, the floodways, and the locations of selected cross sections used in the hydraulic analyses and floodway computations.

7.0 OTHER STUDIES

A Flood Insurance Study for the City of Chewelah has been published previously (Reference 1). The results of this study agree favorably with the results of the previous study.

8.0 LOCATION OF DATA

Information concerning the pertinent data used in the preparation of this study can be obtained by contacting the Chief, Natural and Technological Hazards Division, FEMA, Federal Regional Center, 130 228th Street, SW., Bothell, Washington 98021-9796.

9.0 BIBLIOGRAPHY AND REFERENCES

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EXHIBIT 3 - ELEVATION REFERENCE MARKS

<u>Reference Mark</u>	<u>FIRM Panel</u>	<u>Elevation (Feet NGVD)</u>	<u>Description of Location</u>
RM 1	265	1545.91	"X" chiseled on top of southwest wingwall on Gold Creek Road bridge, across Colville River, approximately 3.3 miles northwesterly of city center, Colville, Washington.
RM 2	265	1549.58	"X" chiseled on north end of the northwest wingwall on State Highway SR 395 bridge across Mill Creek, approximately 2.8 miles northwesterly of city center, Colville, Washington.
RM 3	265	1546.86	"X" on sidewalk at southwest corner of Induco Co. office building, located immediately east of intersection of State Highway SR 395 and Williams Lake Road, 2.3 miles north of city center, Colville, Washington.
RM 4	265	1551.16	Railroad spike in power pole at northeast corner of intersection of Buena Vista Road and State Highway SR 395, 1.4 miles north of city center, Colville, Washington.
RM 5	330	1575.74	Top of fire hydrant at the east end of Fay Road across Colville Valley.
RM 6	330	1548.88	"X" chiseled in top of concrete wingwall at the northwest corner of Fay Road bridge across the Colville River.
RM 7	330	1551.82	Railroad spike in east side power pole on the northeast corner intersection of Fay Road and the west side road.
RM 8	265	1544.92	Railroad spike in power pole at field approach to Valley Westside Road, approximately 1.3 miles north of Fay Road.

EXHIBIT 3 - ELEVATION REFERENCE MARKS

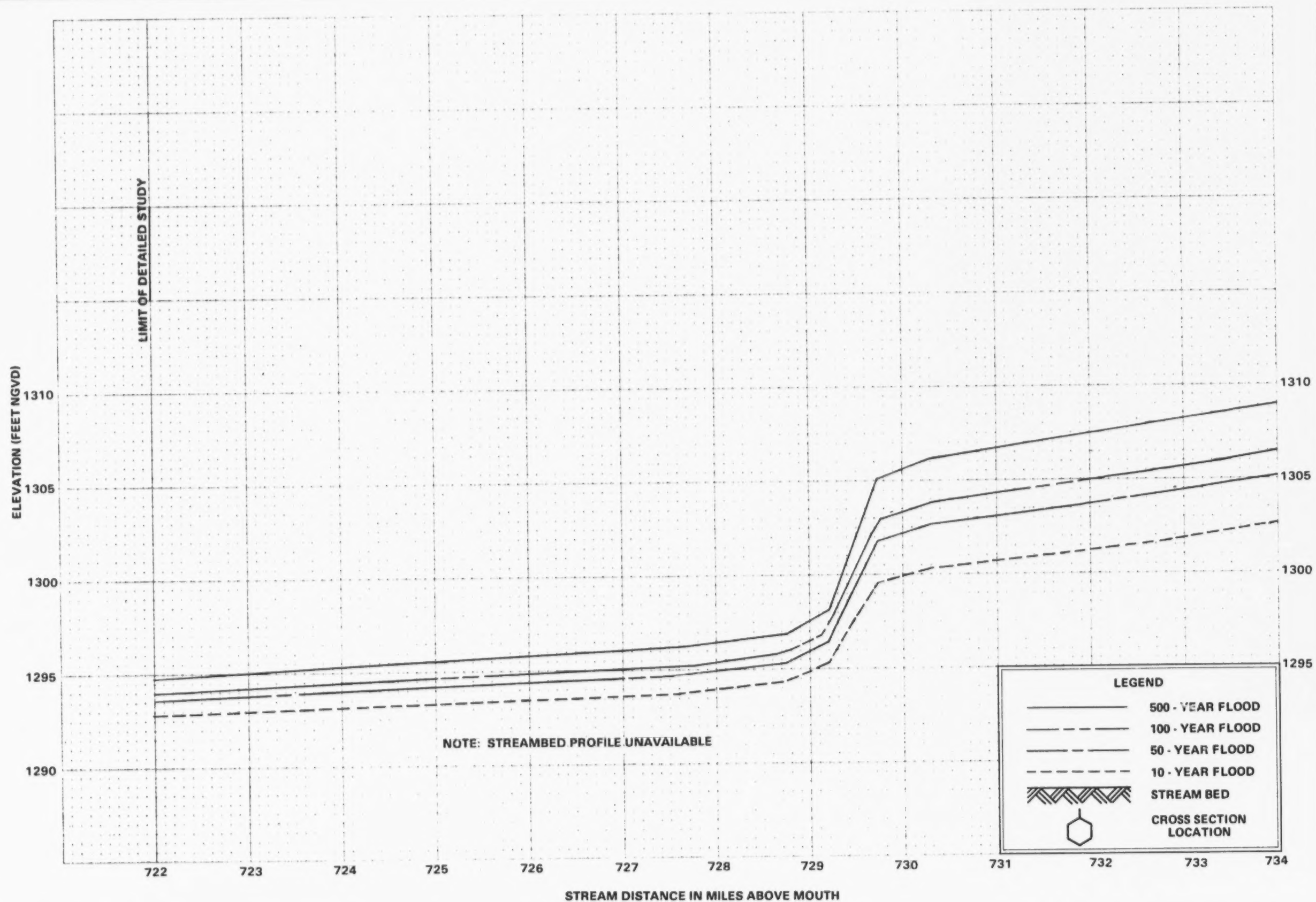
<u>Reference Mark</u>	<u>FIRM Panel</u>	<u>Elevation (Feet NGVD)</u>	<u>Description of Location</u>
RM 9	330	1577.48	Top of fire hydrant at northeast corner intersection of Hawthorne Avenue and Washington Street. (Northwest corner of Southtown Plaza parking lot).
RM 10	330	1554.58	"X" stamped on 3.5-inch brass disk set in bridge timber (painted white) at southwest corner span on Burlington Northern Railroad bridge across Colville River.
RM 11	330	1554.82	"X" chiseled in top of concrete wingwall at the northeast corner of Mantz-Rickey Road bridge across Colville River.
RM 12	440	1784.73	"X" 1987 stamped on upstream end of culvert at intersection of North Fork Chewelah Creek and Chewelah Creek Road, northwesterly of Jack Parry's house, approximately 2.4 miles north of city center, Chewelah, Washington.
RM 13	440	1754.85	U.S. coast geodetic benchmark at the east side of the intersection of Sand Canyon Road and Kramer County Road, approximately 1.8 miles north of city center, Chewelah, Washington.
RM 14	440	1742.38	"X" 1987 stamped in downstream end of culvert at the intersection of Paye Creek and Kramer County Road, approximately 0.5 mile east of State Highway SR 395, 2.3 miles north of city center, Chewelah, Washington.
RM 15	440	1733.16	"X" chiseled in top of concrete wingwall at northeast corner of private bridge on North Fork Chewelah Creek at Manus driveway, 100 feet east of North Fork Chewelah Creek Road, and 1.5 miles north of city center, Chewelah, Washington.

EXHIBIT 3 - ELEVATION REFERENCE MARKS

<u>Reference Mark</u>	<u>FIRM Panel</u>	<u>Elevation (Feet NGVD)</u>	<u>Description of Location</u>
RM 16	440	1699.85	"X" 1987 stamped on downstream end of most easterly culvert in Paye Creek on State Highway SR 395, 1 mile north of Chewelah, Washington.
RM 17	440	1700.14	"X" 1987 stamped on downstream end of culvert at the intersection of North Fork Chewelah Creek and Salsman Road, 1 mile north of city center, Chewelah, Washington.
RM 18	440	1731.16	Railroad spike in power pole 1,600 feet east of Cozy Nook Road on the south side of Salsman Road.
RM 19	440	1760.34	"X" 1987 stamped on upstream end of culvert at the intersection of the west branch of South Fork Chewelah Creek and Burnt Valley Road, 1.6 miles north of city center, Chewelah, Washington.
RM 20	440	1816.75	"X" 1987 stamped on steel girder at the northwest corner of Hjalmar Mydland's bridge on South Fork Chewelah Creek near the center of Section 1, Township 32 north, range 40 east, approximately 2.5 miles north of city center, Chewelah, Washington, 0.2 mile west of Burnt Valley Road.
RM 21	420	1637.94	"X" chiseled in top of concrete wingwall at southeast corner of Steinmetz Bridge across Colville River.
RM 22	420	1662.95	West rail Burlington Northern Railroad at intersection of centerline of Nevin Road, 0.36 mile east of Schmidelkofer Bridge across the Colville River.
RM 23	440	1635.55	"X" chiseled in top of concrete wingwall at southeast corner of Schmidelkofer Bridge across Colville River.

EXHIBIT 3 - ELEVATION REFERENCE MARKS

<u>Reference Mark</u>	<u>FIRM Panel</u>	<u>Elevation (Feet NGVD)</u>	<u>Description of Location</u>
RM 24	505	1639.69	"X" stamped on steel I-beam on wingwall at the southeast corner of Alm Lane Bridge across the Colville River, approximately 1.7 miles southwest of the city center, Chewelah, Washington.
RM 25	505	1649.20	One-half galvanized bolt driven in high voltage power pole on south side of county road at corner, approximately 0.8 mile east of Alm Lane Bridge across Colville River.
RM 26	505	1647.55	"X" chiseled in top of concrete curb on northeast corner of State Highway SR 395 bridge across Colville River, approximately 1 mile south of city center, Chewelah, Washington.



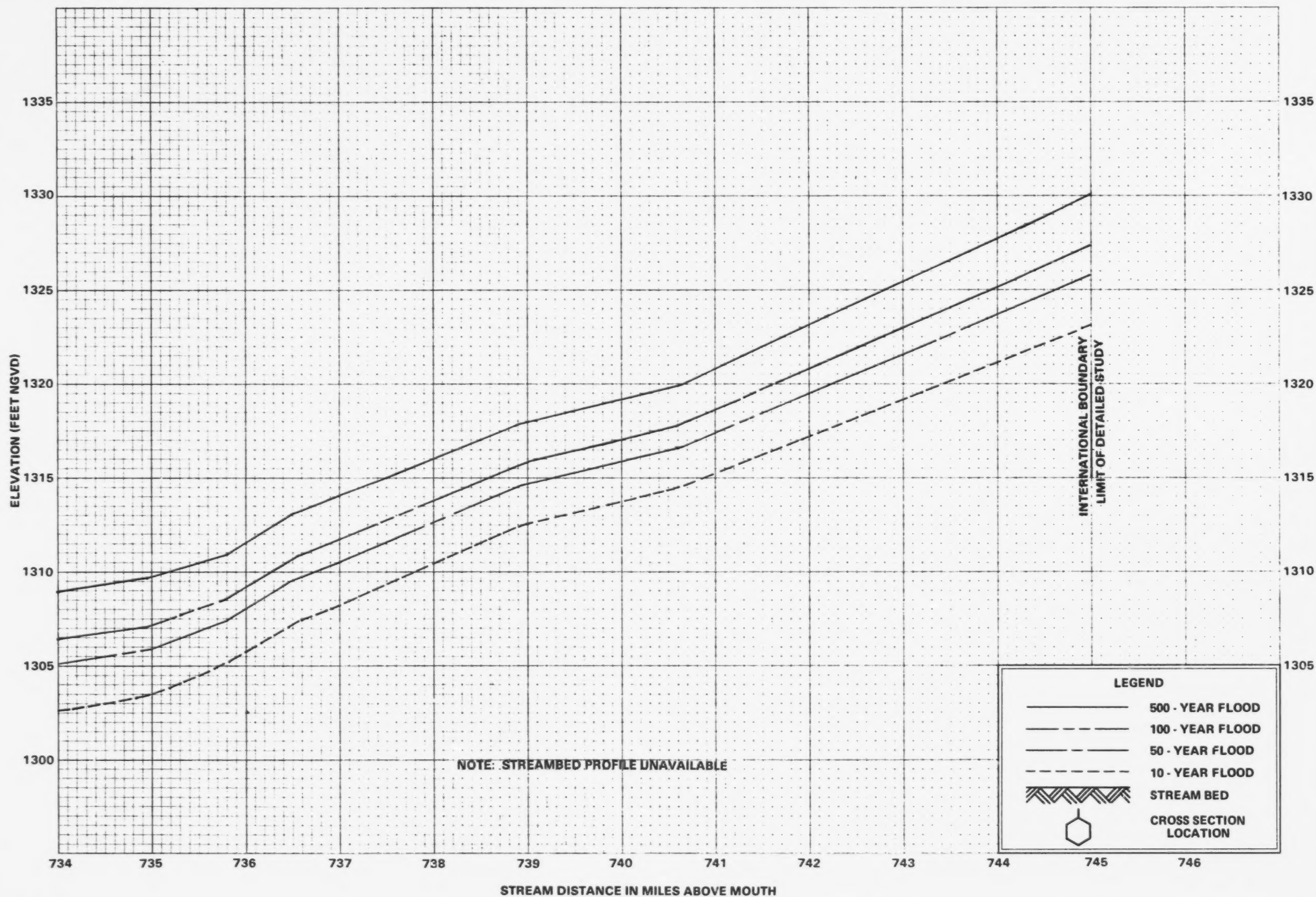
FLOOD PROFILES

COLUMBIA RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

STEVENS COUNTY, WA
(UNINCORPORATED AREAS)

01P



FLOOD PROFILES

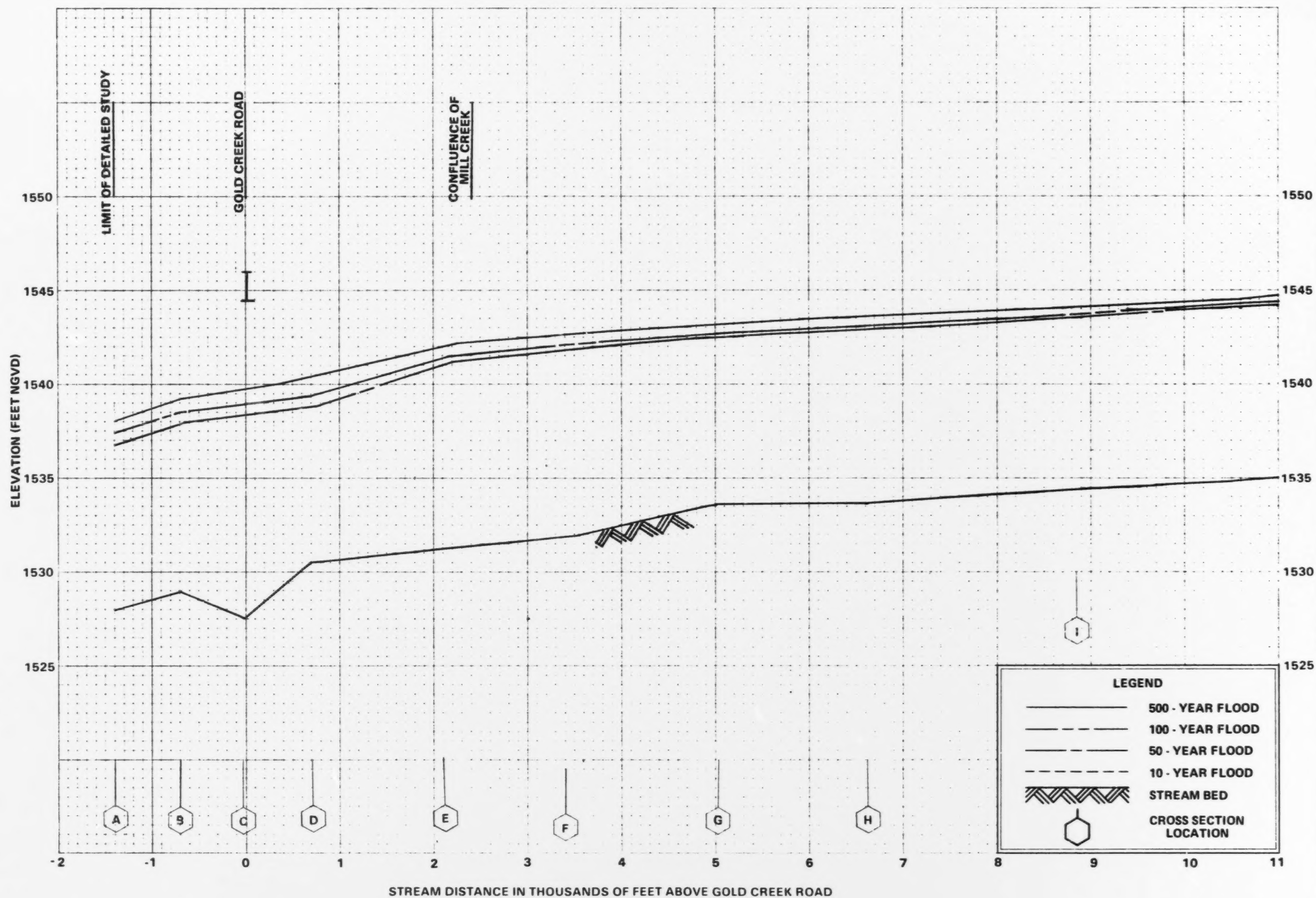
COLUMBIA RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

STEVENS COUNTY, WA

(UNINCORPORATED AREAS)

02P

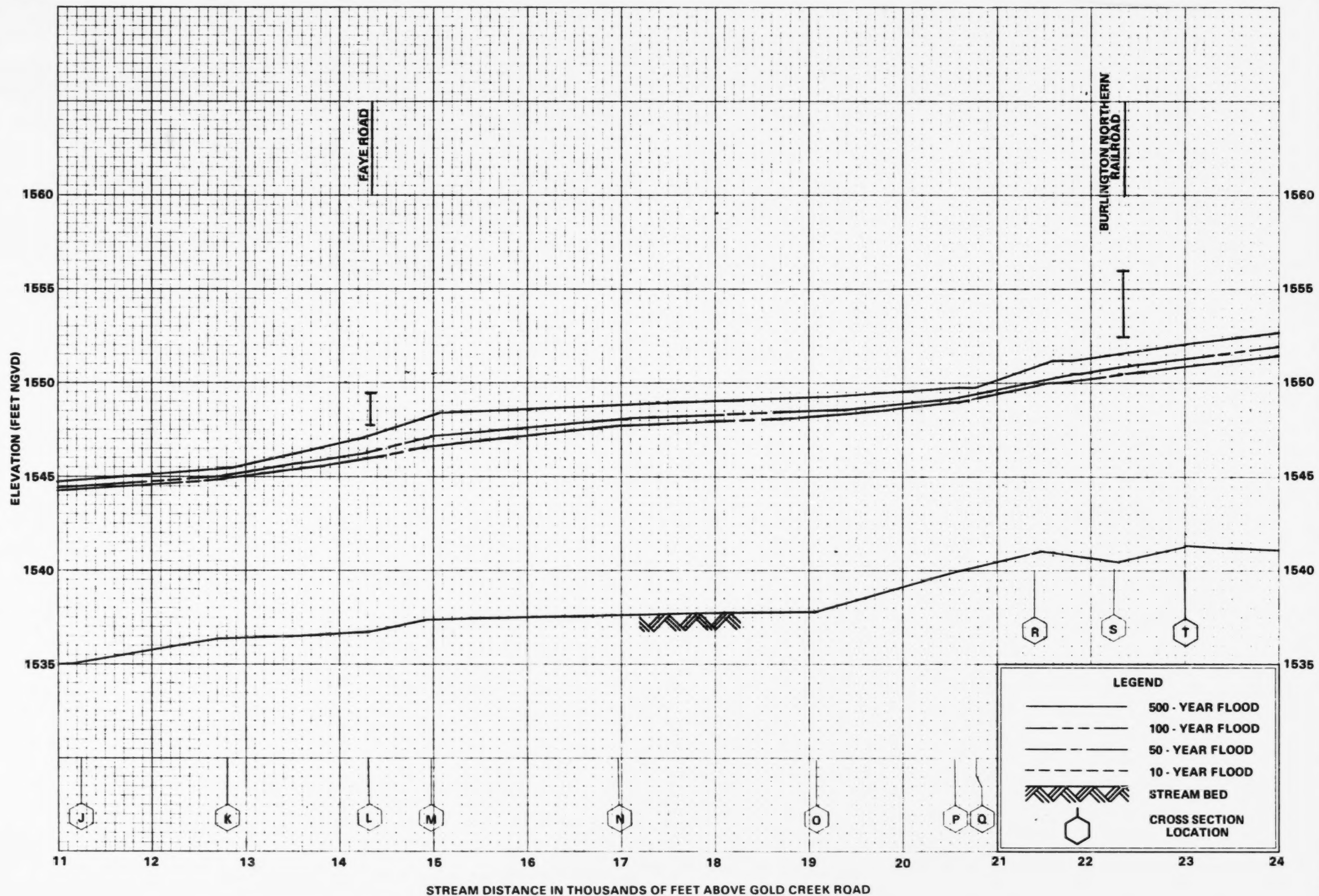


FLOOD PROFILES

COLVILLE RIVER NEAR COLVILLE, WASHINGTON

FEDERAL EMERGENCY MANAGEMENT AGENCY
STEVENS COUNTY, WA
 (UNINCORPORATED AREAS)

03P



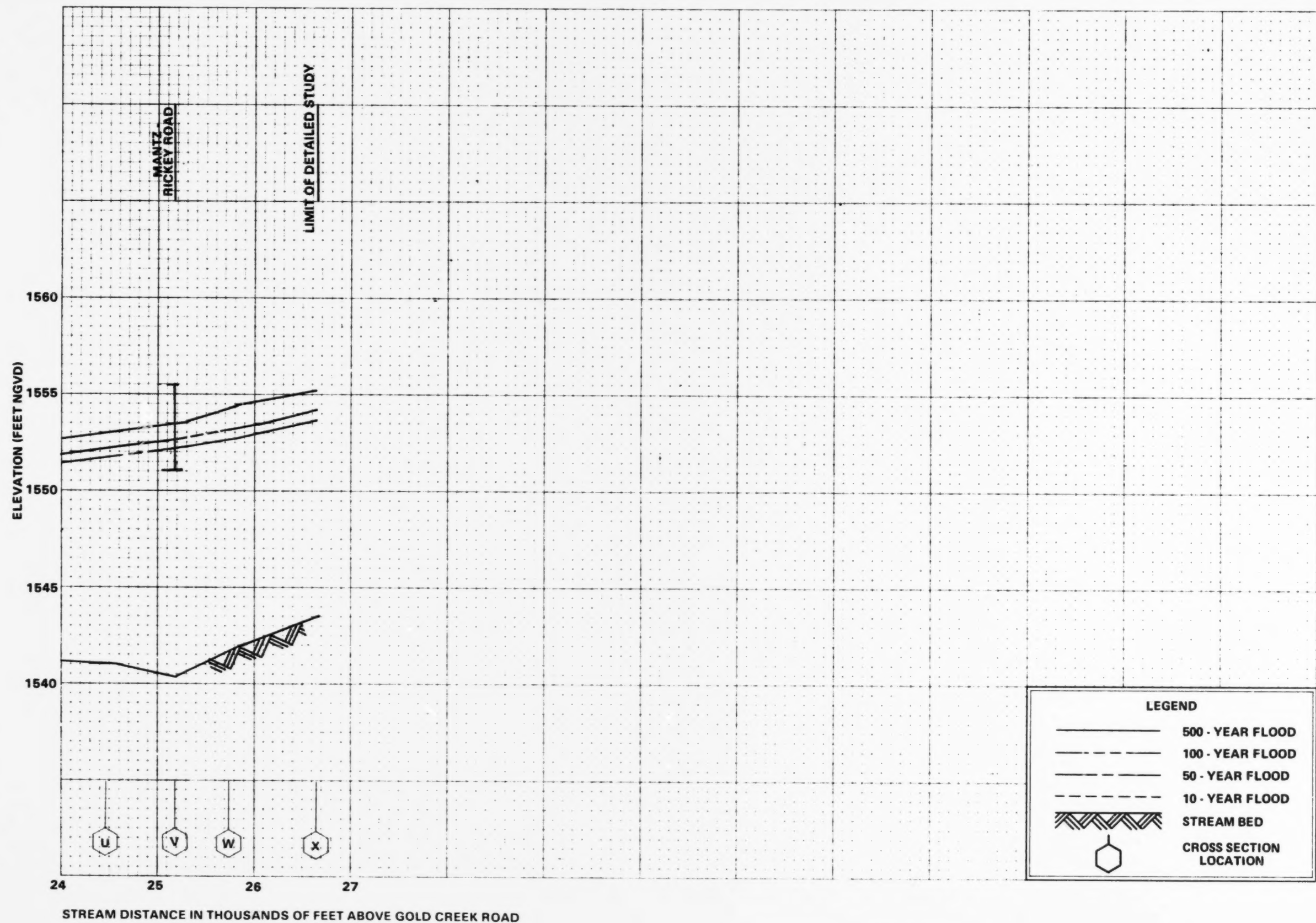
FLOOD PROFILES

COLVILLE RIVER NEAR COLVILLE, WASHINGTON

FEDERAL EMERGENCY MANAGEMENT AGENCY

STEVENS COUNTY, WA
(UNINCORPORATED AREAS)

04P



FLOOD PROFILES

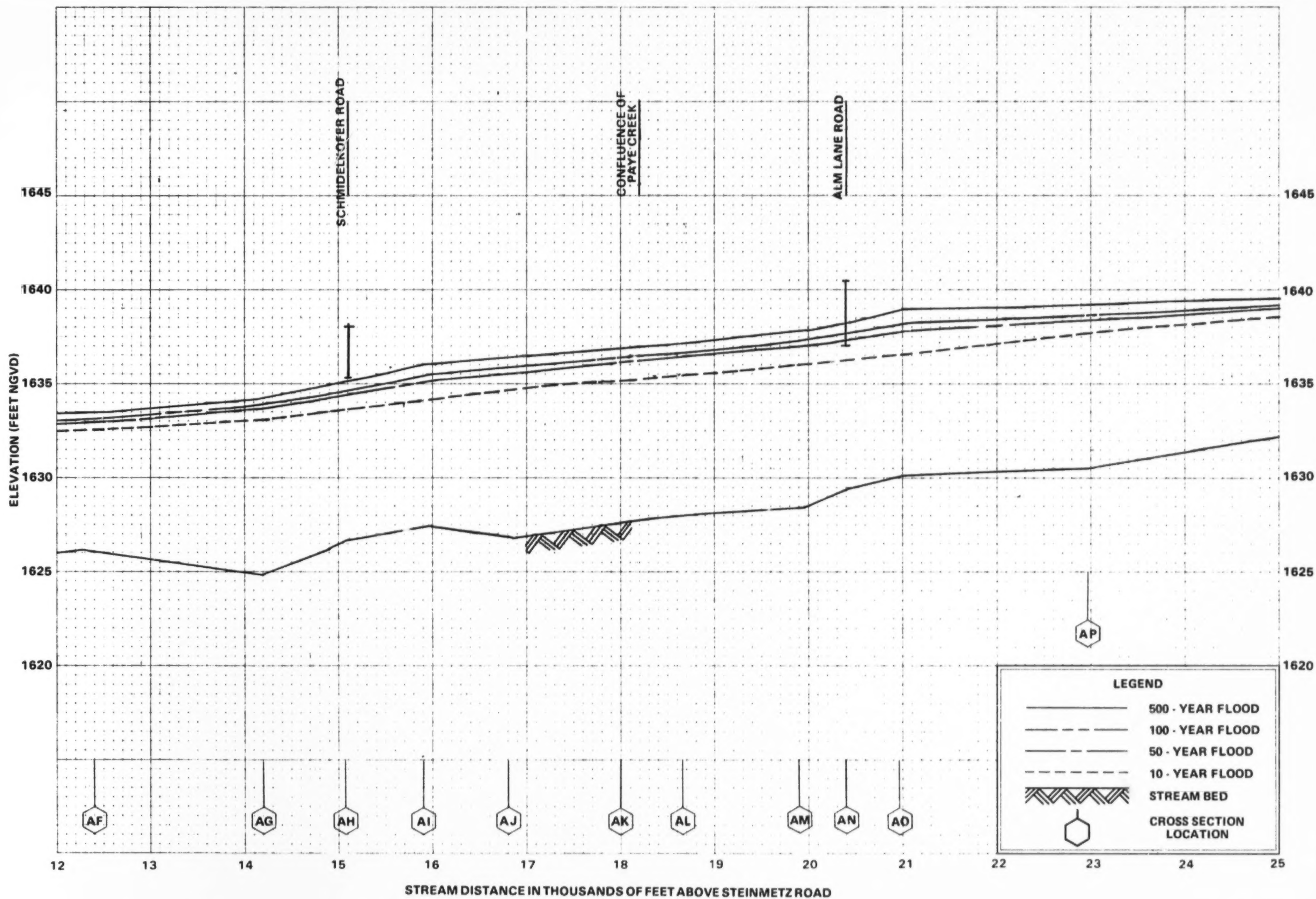
COLVILLE RIVER NEAR COLVILLE, WASHINGTON

FEDERAL EMERGENCY MANAGEMENT AGENCY

STEVENS COUNTY, WA
(UNINCORPORATED AREAS)

05P

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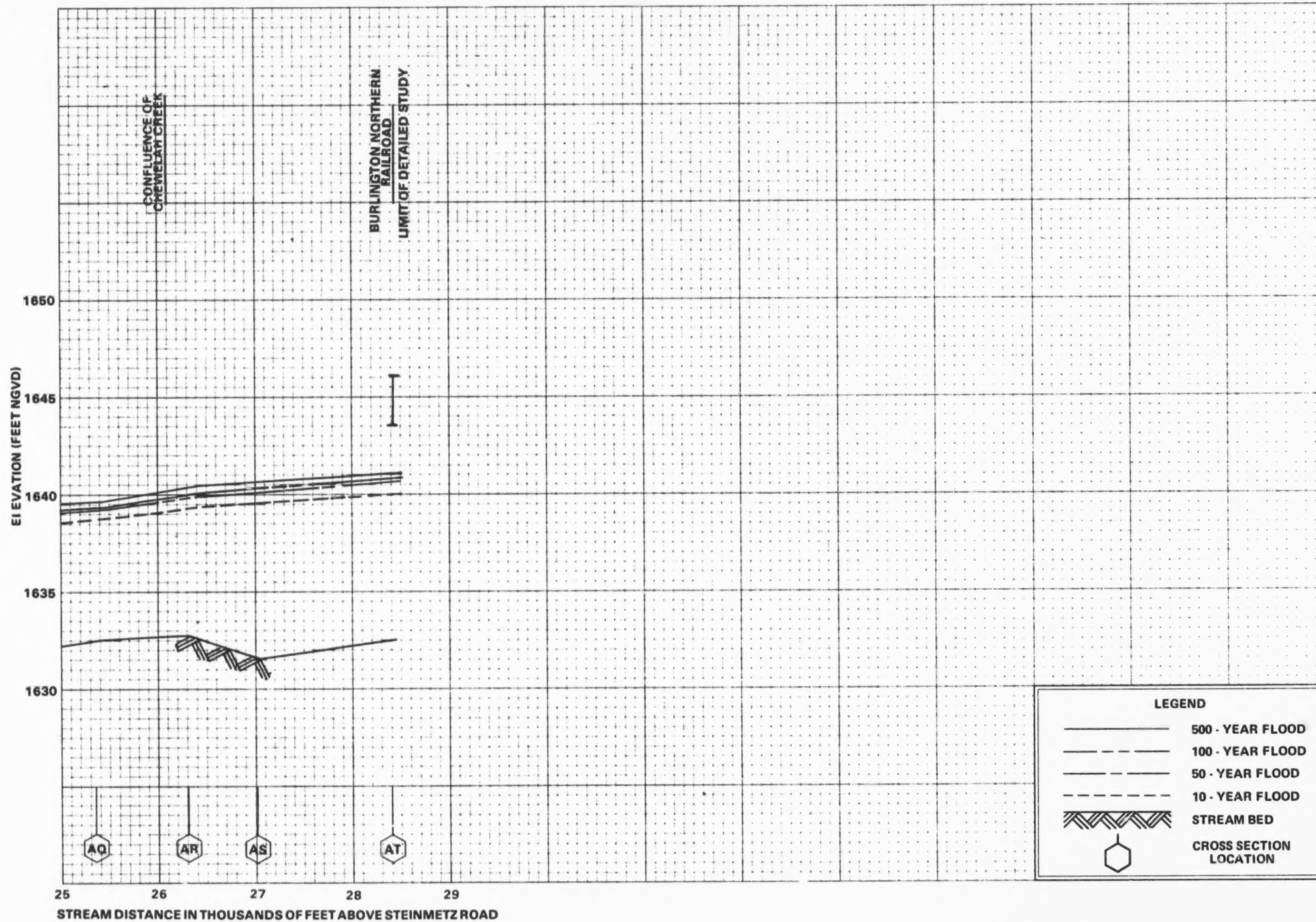
FLOOD PROFILES

COLVILLE RIVER NEAR CHEWELAH, WASHINGTON

FEDERAL EMERGENCY MANAGEMENT AGENCY

STEVENS COUNTY, WA
(UNINCORPORATED AREAS)

07P



FLOOD PROFILES

COLVILLE RIVER NEAR CHEWELAH, WASHINGTON

FEDERAL EMERGENCY MANAGEMENT AGENCY

STEVENS COUNTY, WA
(UNINCORPORATED AREAS)

08P